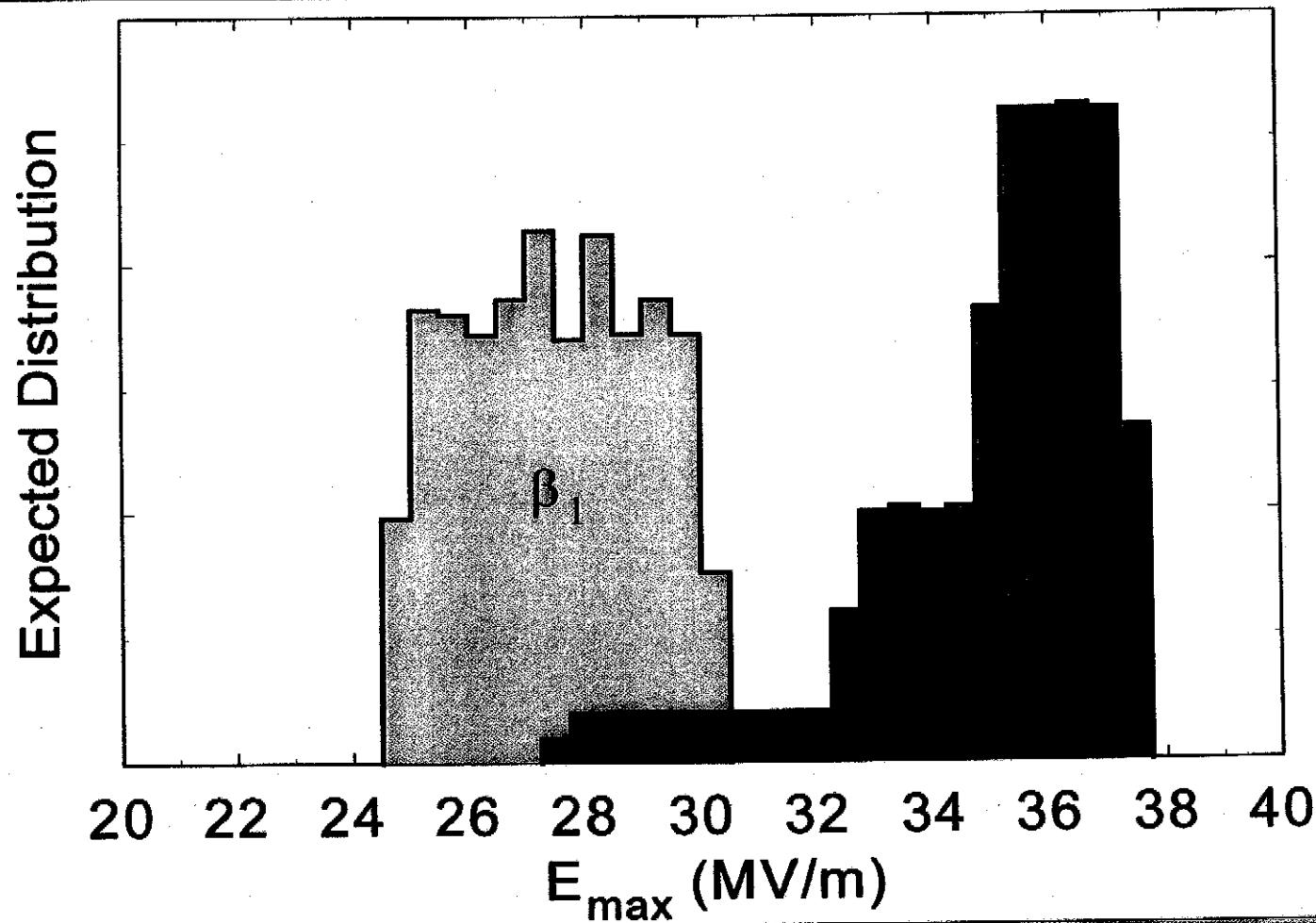

Some Aspects of Beam Behavior in the SNS Linac

S. Nath

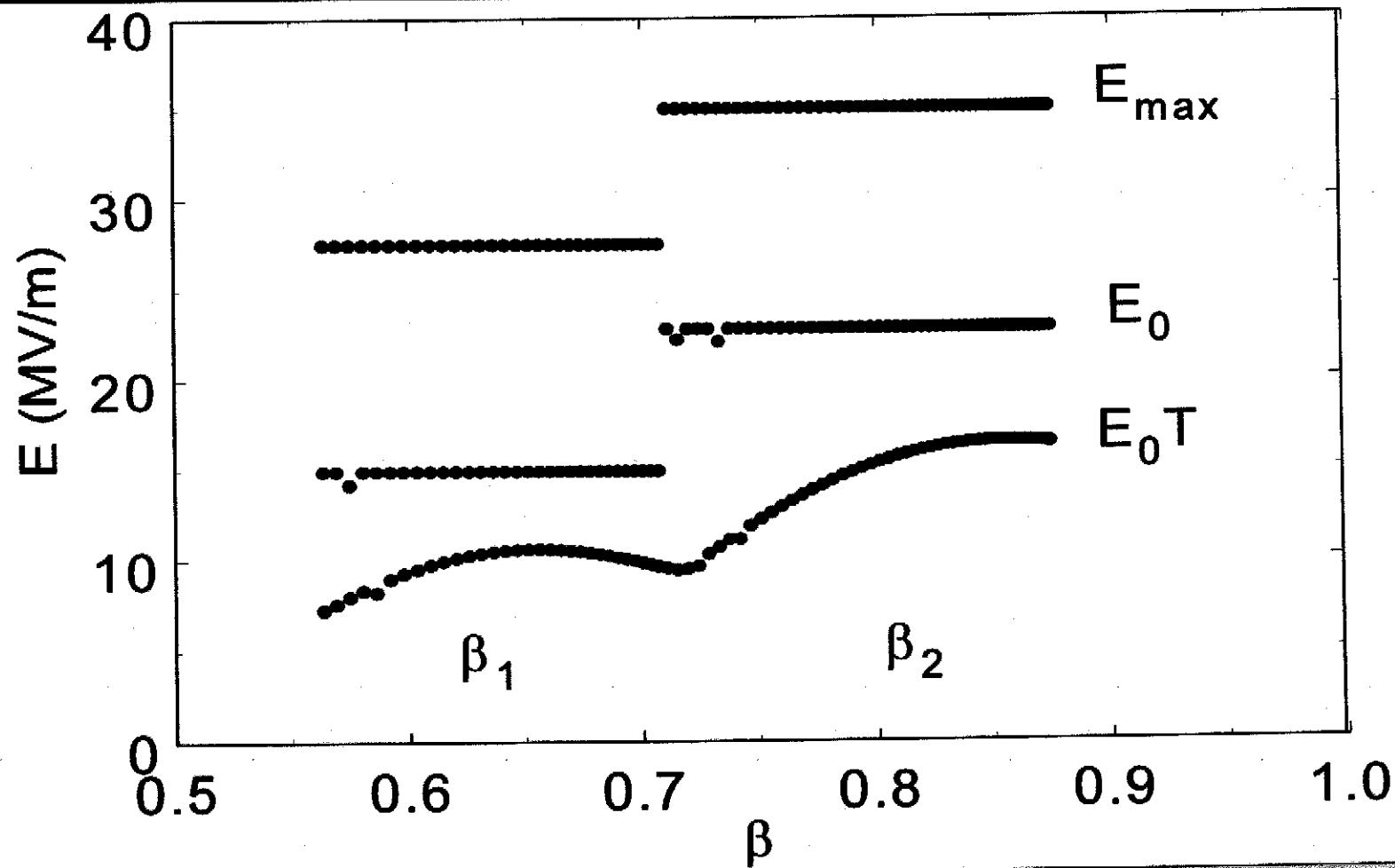
Los Alamos National Laboratory

9 April 2002

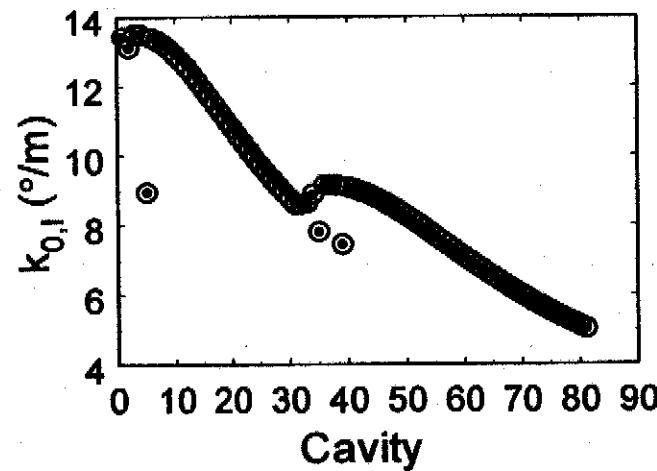
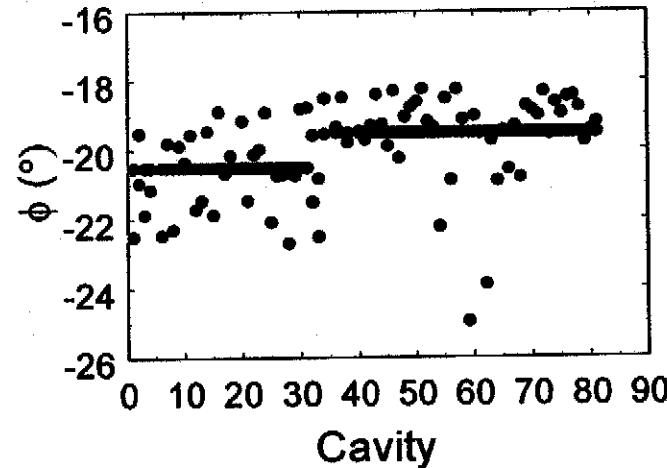
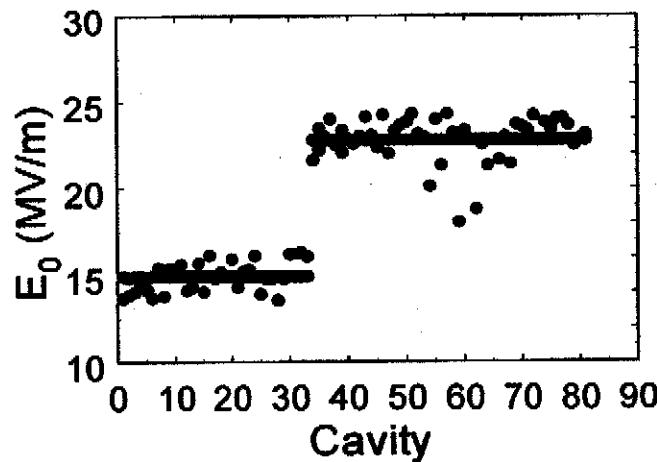
Expected (a la TJNAF) SRF-Cavity Design β Distributions



The SRF Linac Design Uses the Mean Values of the Predicted Cavity Fields



Design Philosophy: Set $\phi_s = \phi(E_0)$ for Each Cavity to Preserve $k_{0,i}$



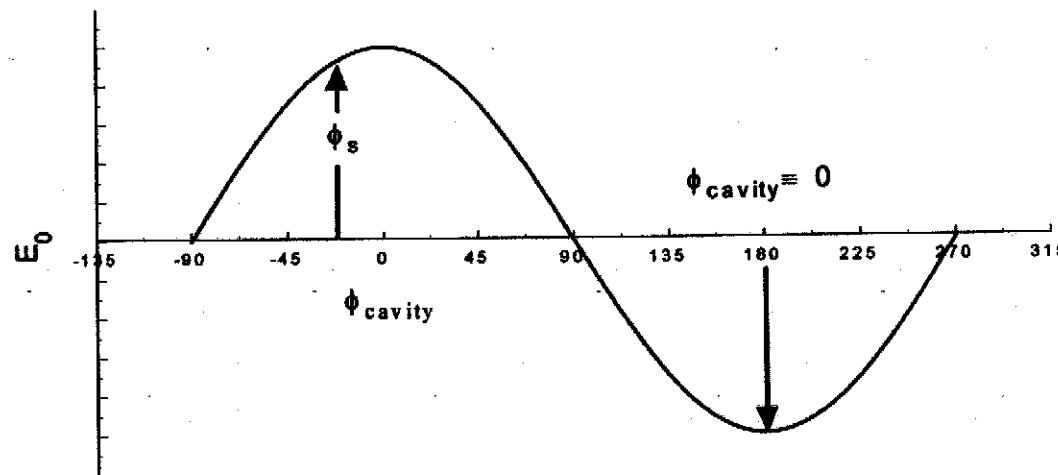
- design value
- tuning example

This Approach Requires Knowledge of E_0 to Derive ϕ_s

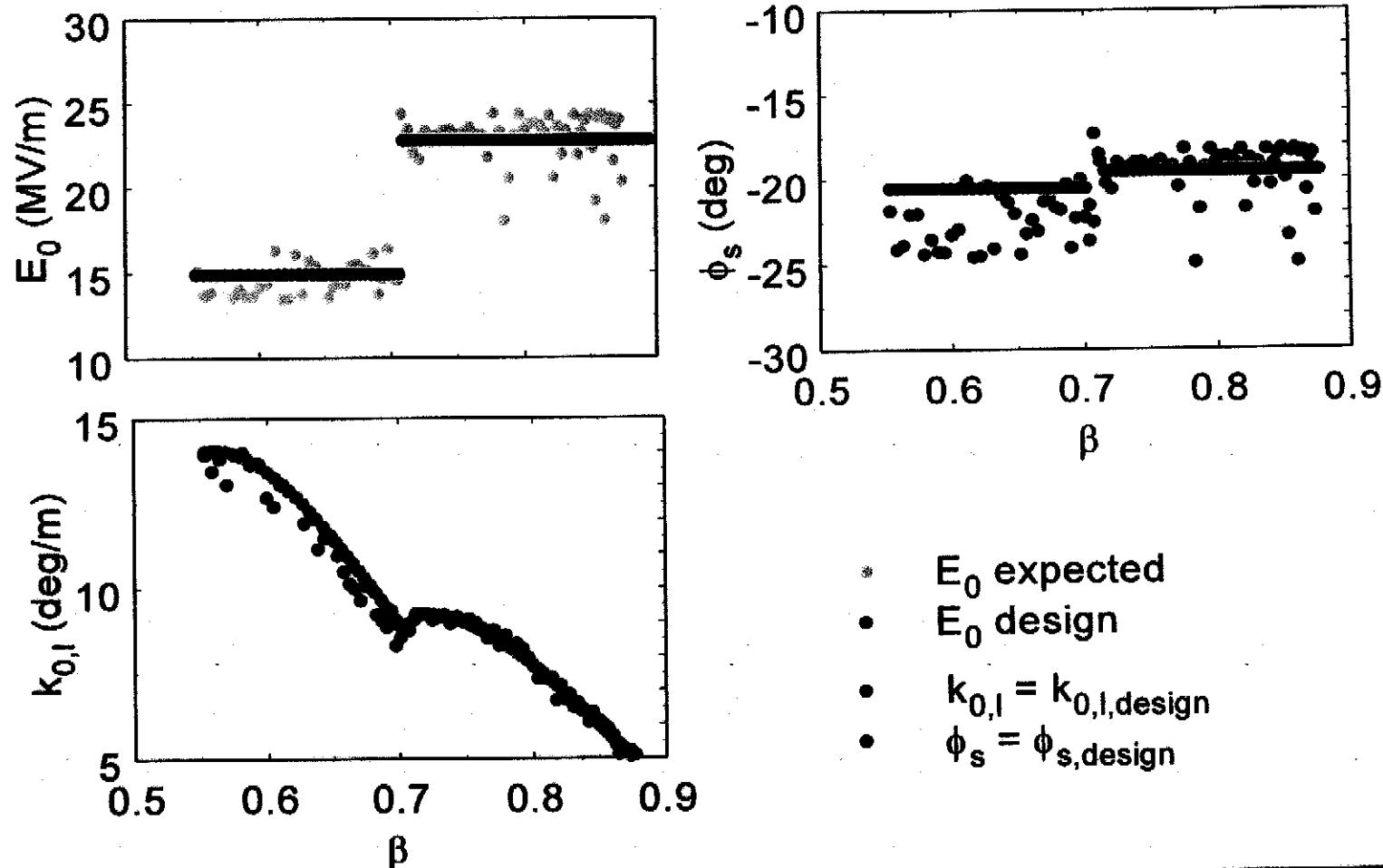
- Calibrate rf field loops of first cavity
 - drifting beam excites cavity
 - corresponding E_0 is defined by TRANS calculations
 - $\phi_{\text{cavity}} = \phi_{\text{beam}} - 180^\circ$
 - Set E_0 set point using calibrated loop
 - Derive and set $\phi_{\text{operating}}$, cavity phase set point
 - Turn on rf & accelerate beam
 - Calibrate rf field loops of next cavity
 - set E_0 and $\phi_{\text{operating}}$ setpoints of next cavity
 - turn on rf & accelerate beam
 - Repeat until all cavities are set
 - Periodically check W_{beam} with time-of-flight measurements
 - Periodically resteer & rematch beam to minimize loss
-

A Drifting Beam Excites a Cavity at 180°

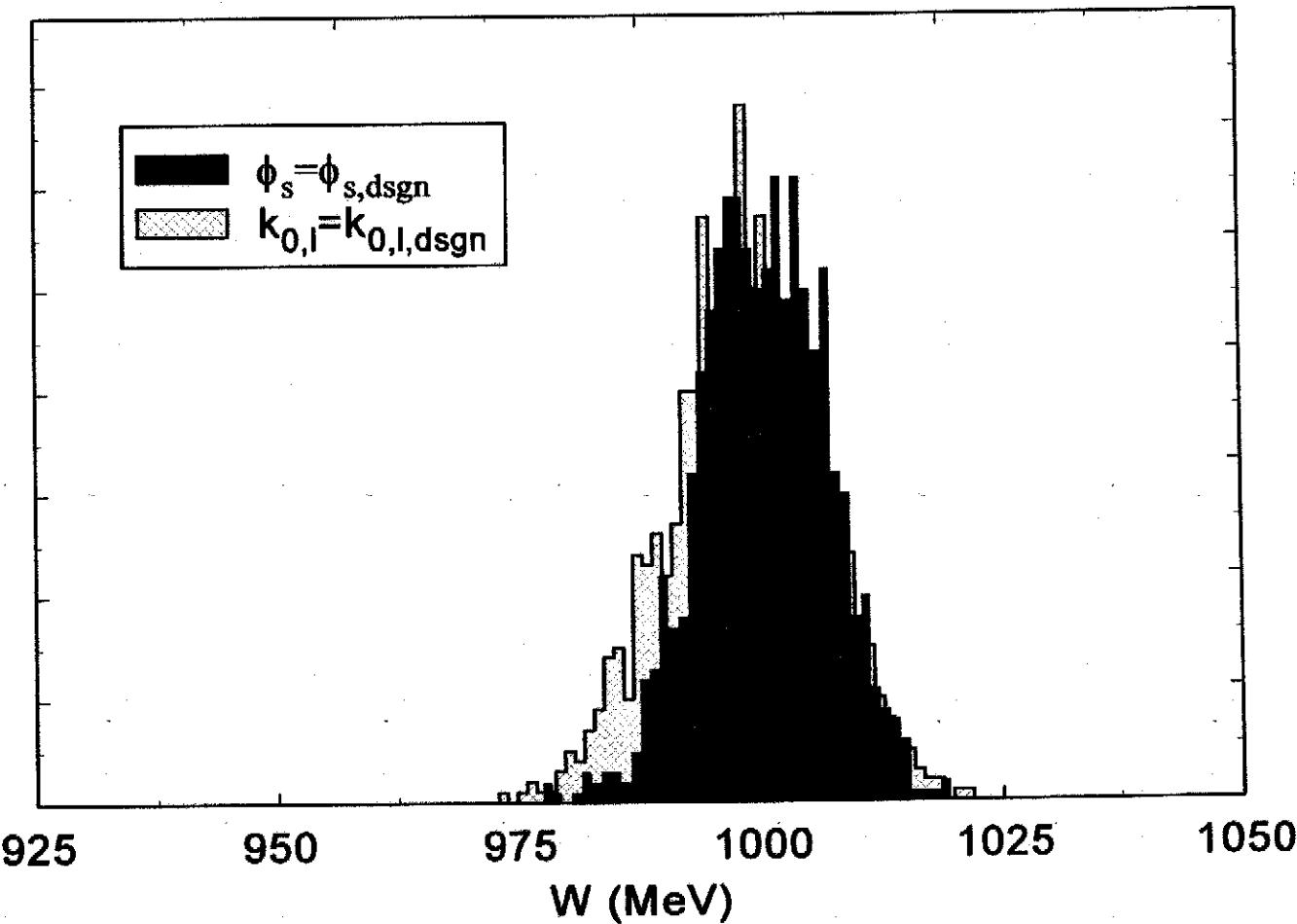
- By definition a drifting beam excites fields in a cavity at 180°
- This defines the cavity phase relative to the beam and to the phase reference line
- The phase is then adjusted to ϕ_s for acceleration
- No BPM phase measurements are required



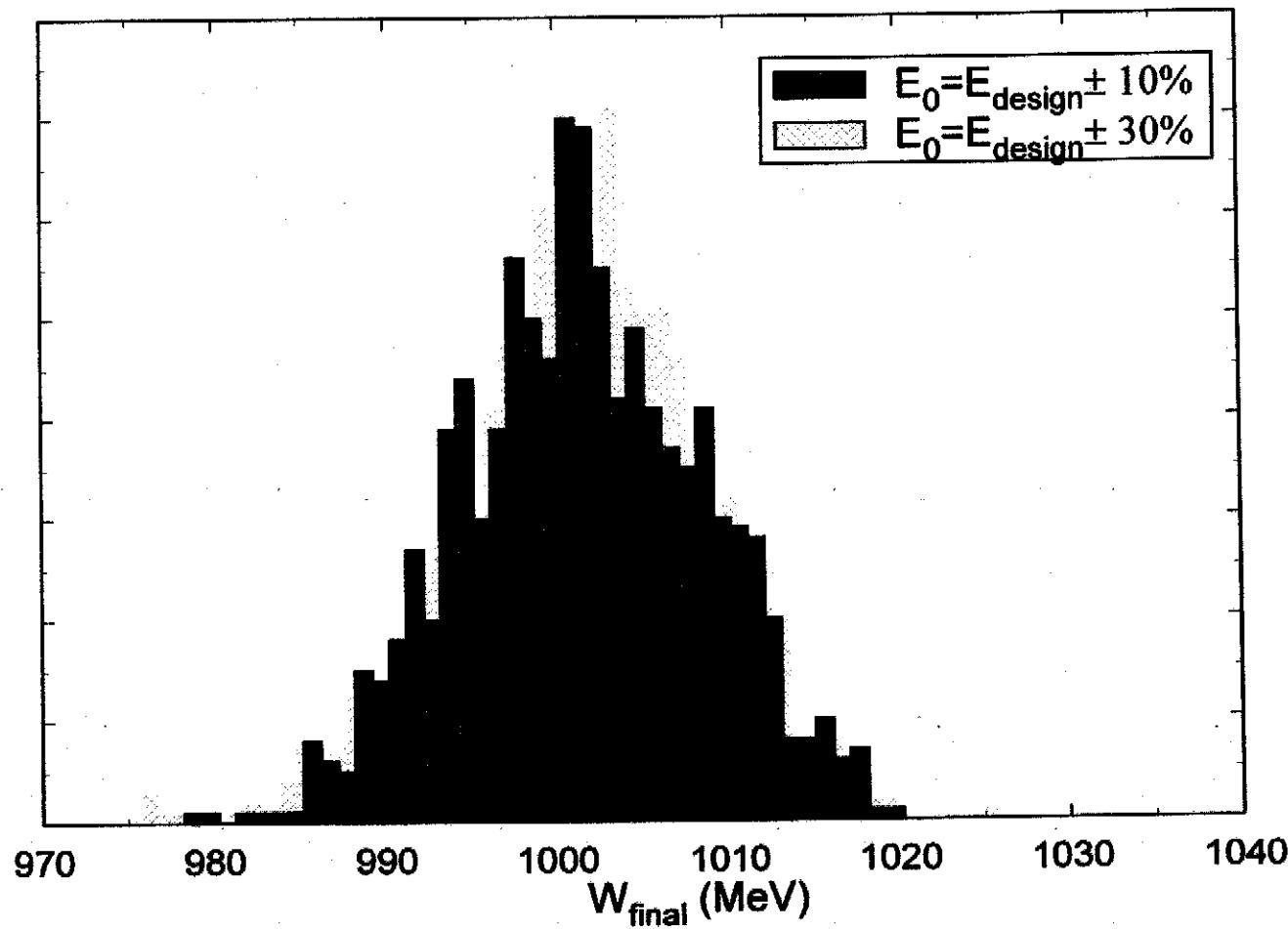
Constant ϕ_s is a Deviation from Design Tune -- Results in a Distributed Longitudinal Mismatch



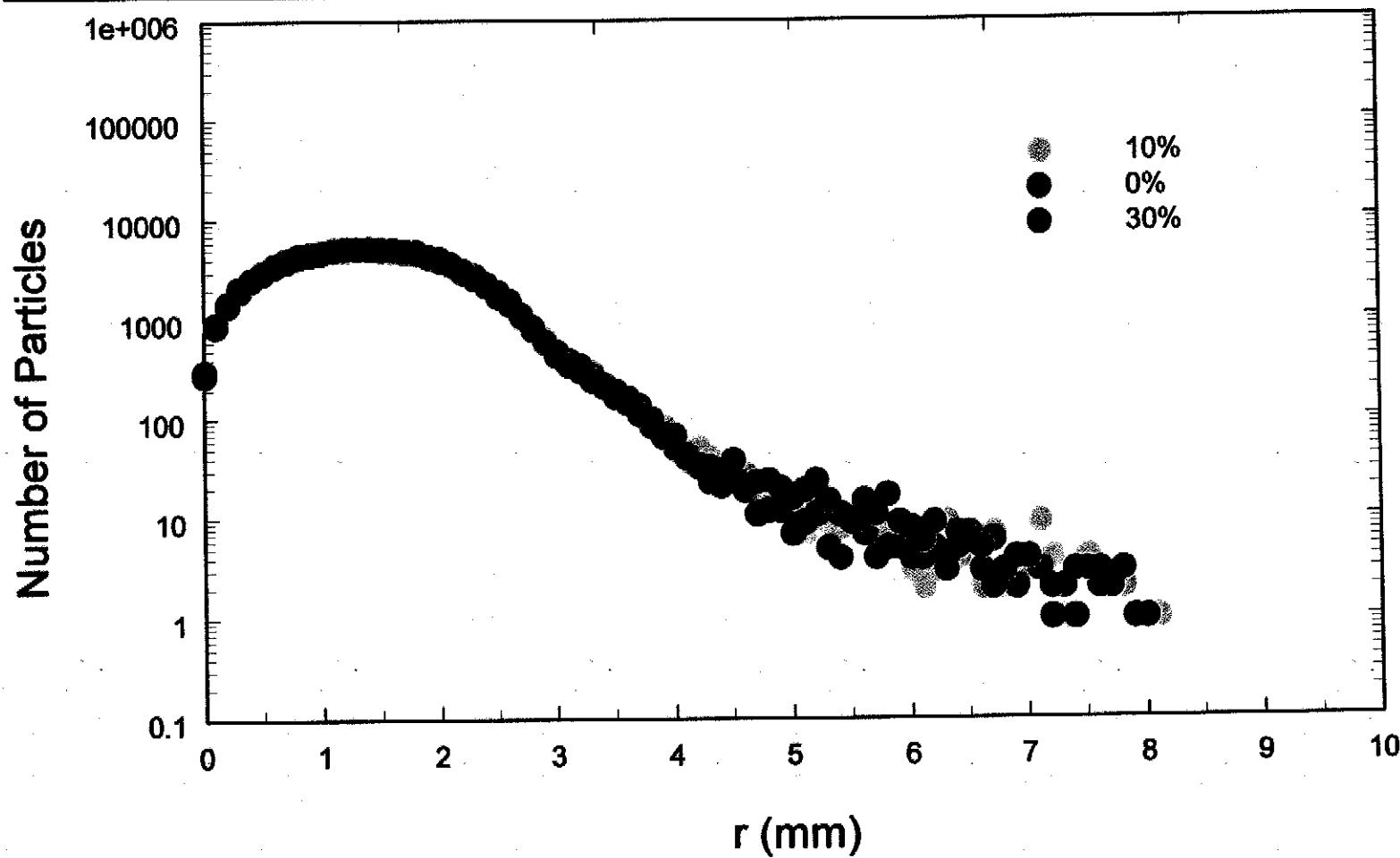
W_{final} Distribution for E_0 and $E_0 \pm 10\%$ do not Show Difference in Energy Spread



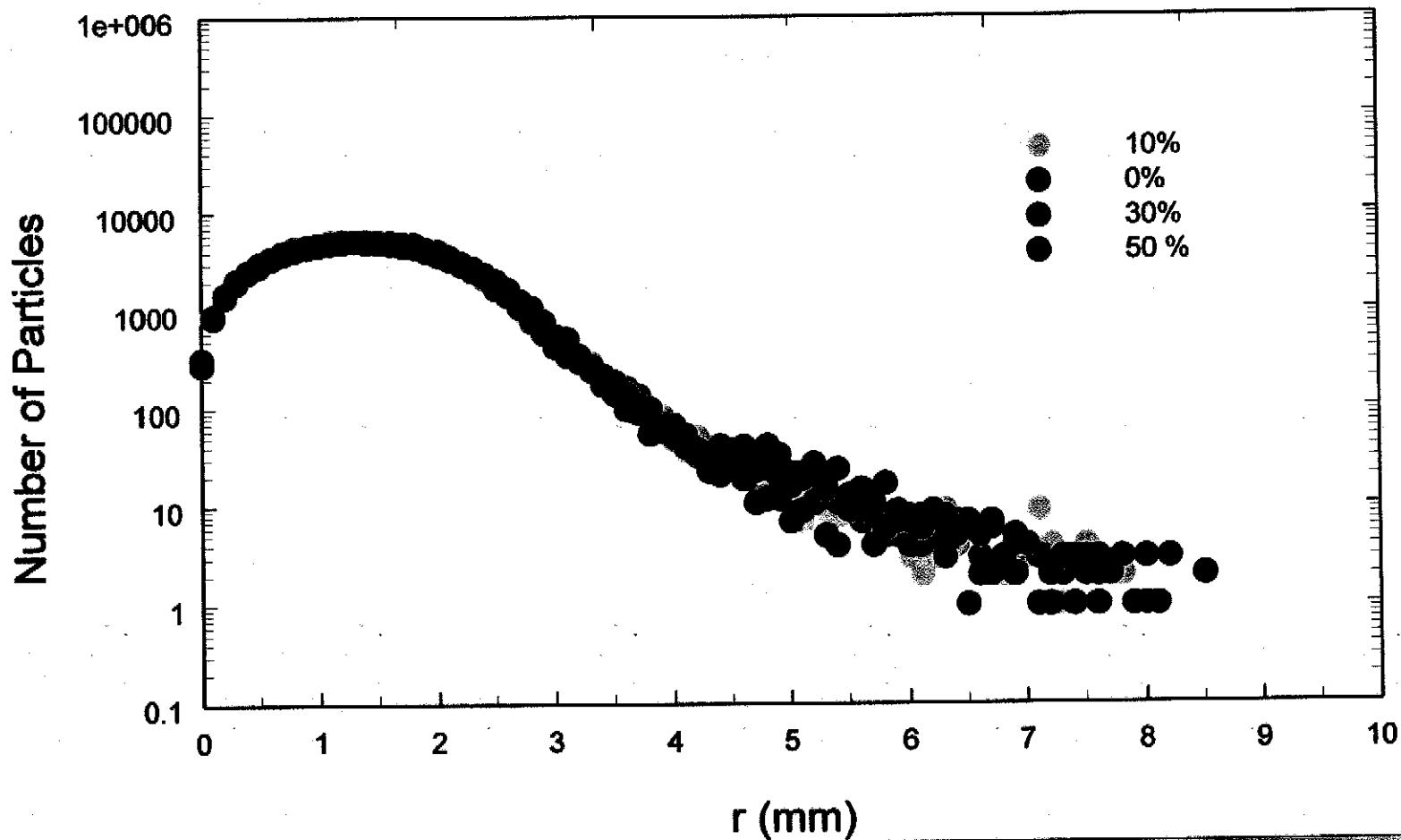
Same True for $E_0 \pm 10\%$ and $E_0 \pm 30\%$ W_{final} Distributions



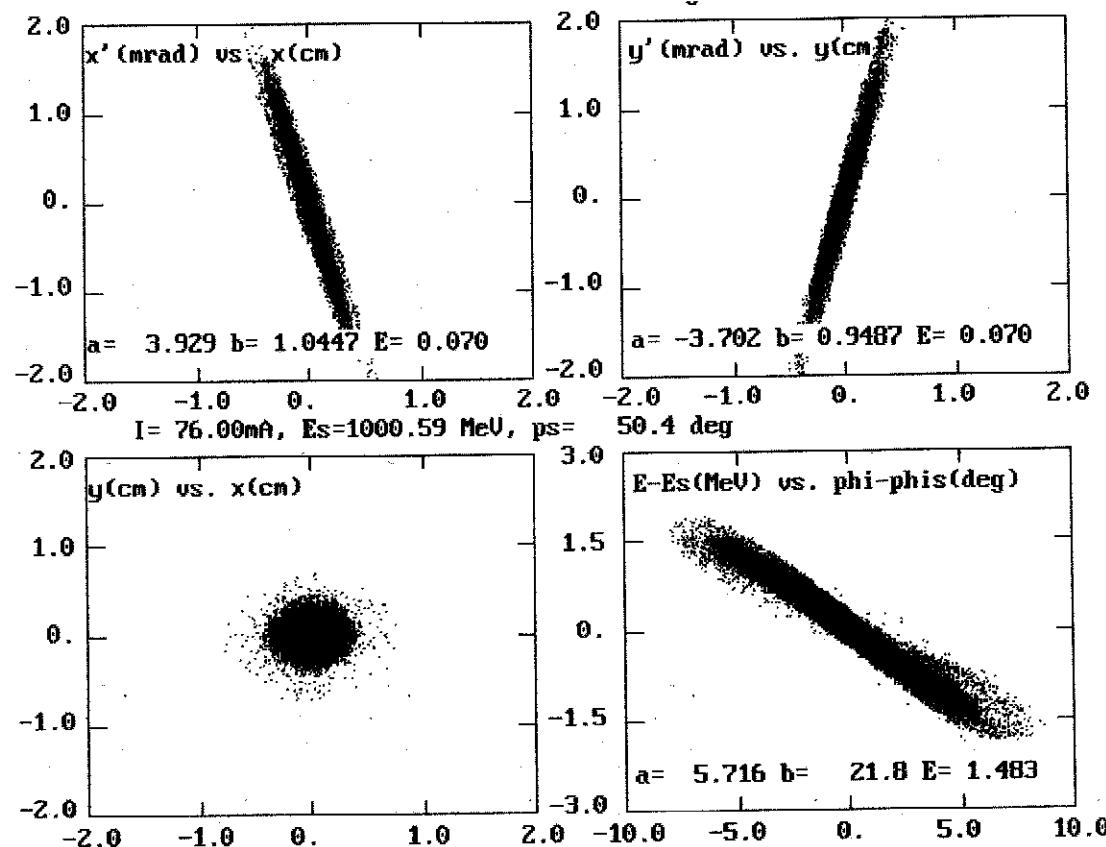
Radial Distributions at the End of SRF Linac for E_0 , $E_0 \pm 10\%$, $E_0 \pm 30\%$ are Barely Distinguishable



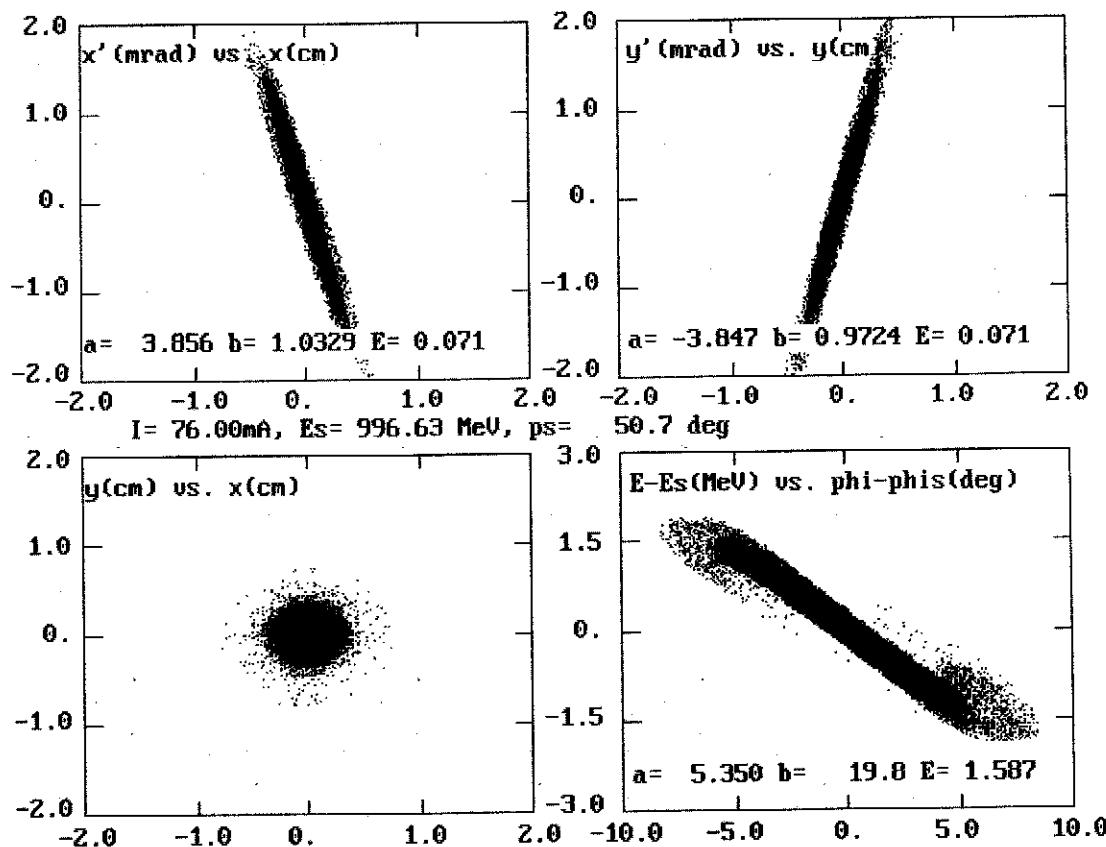
Even for $E_0 \pm 50\%$, Radial Distribution is not Far Off



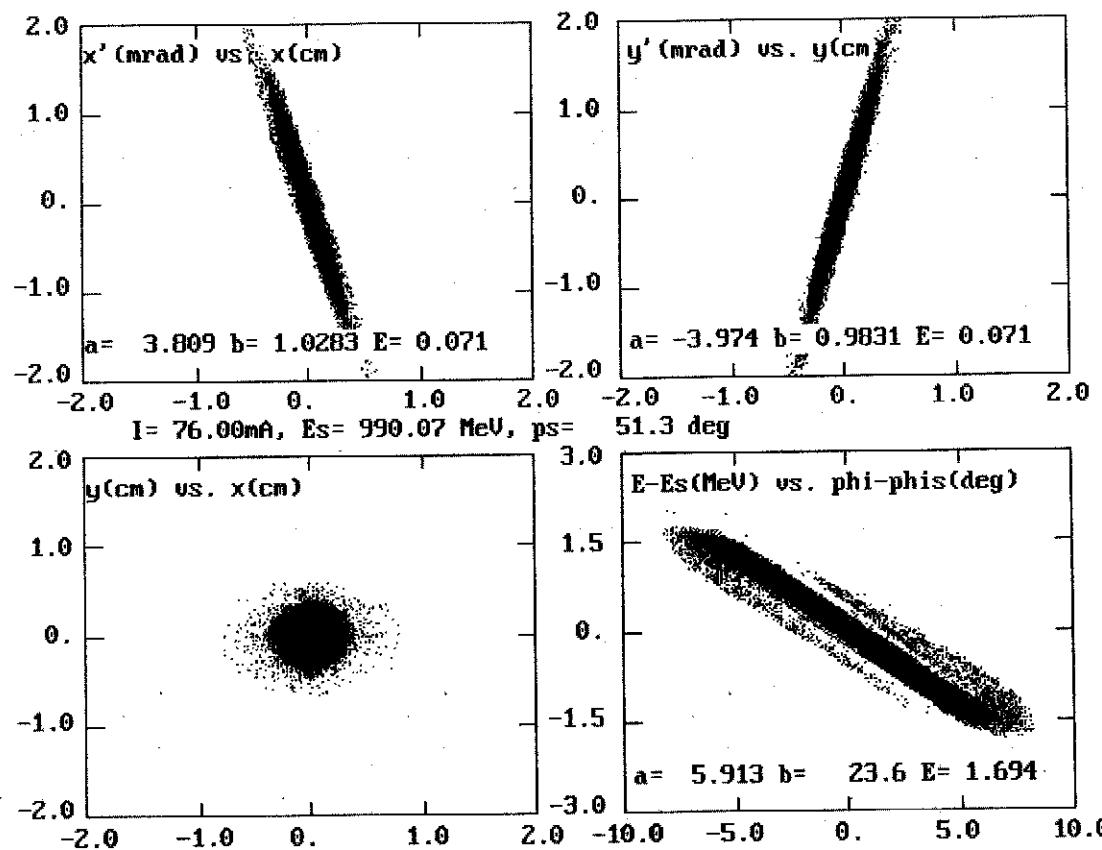
Phase Space Projections at Linac End for the Design Case



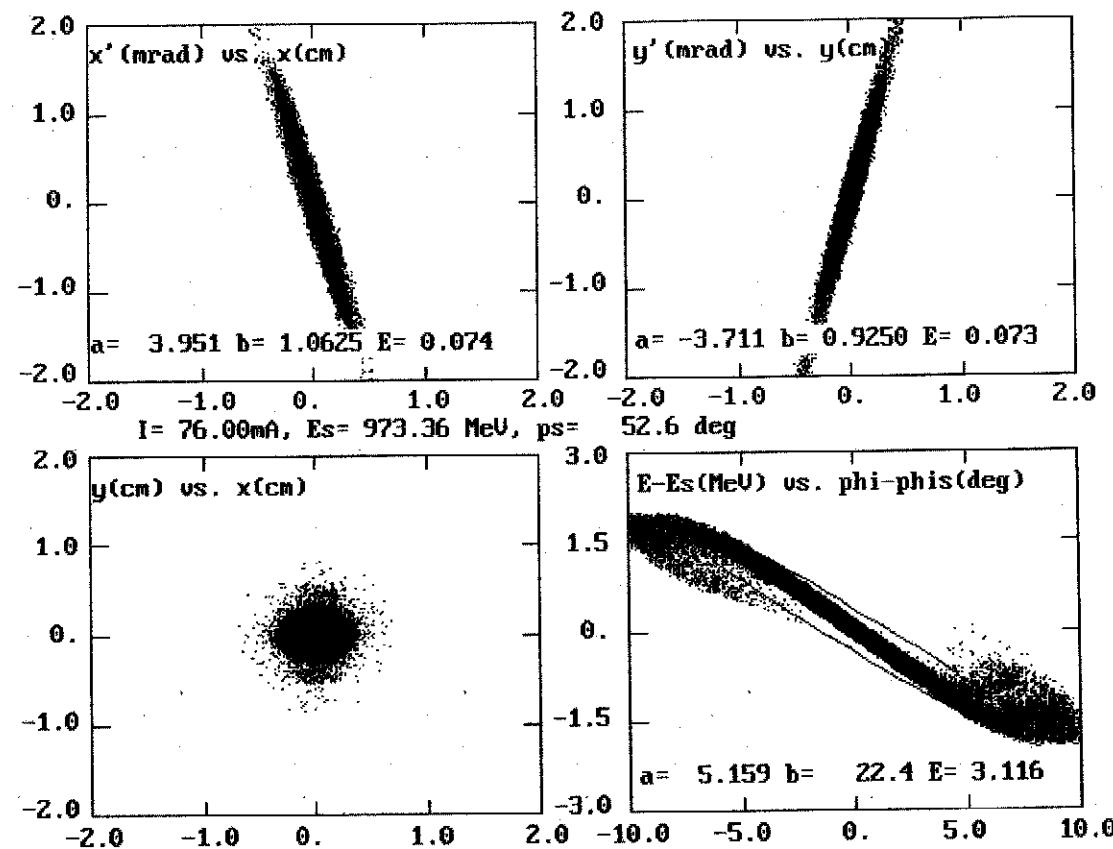
Phase Space Projections at Linac End for the $E_0 \pm 10\%$ Case



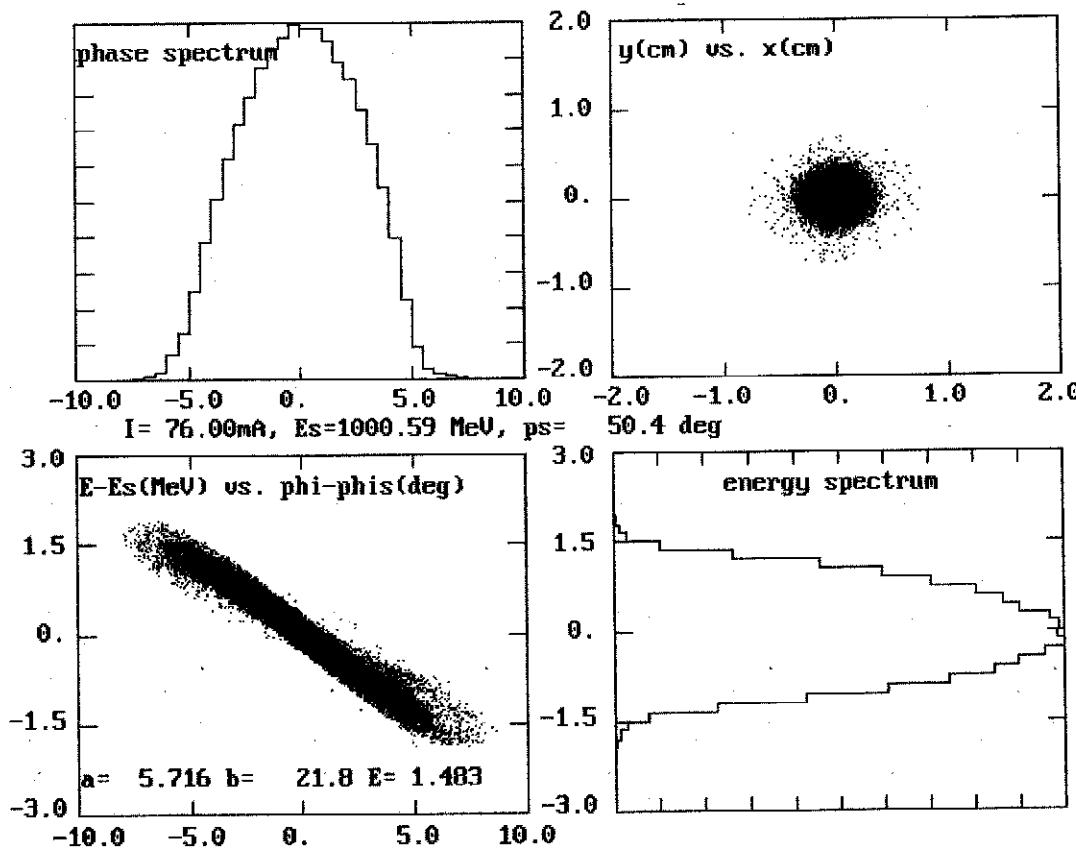
Phase Space Projections at Linac End for the $E_0 \pm 30\%$ Case



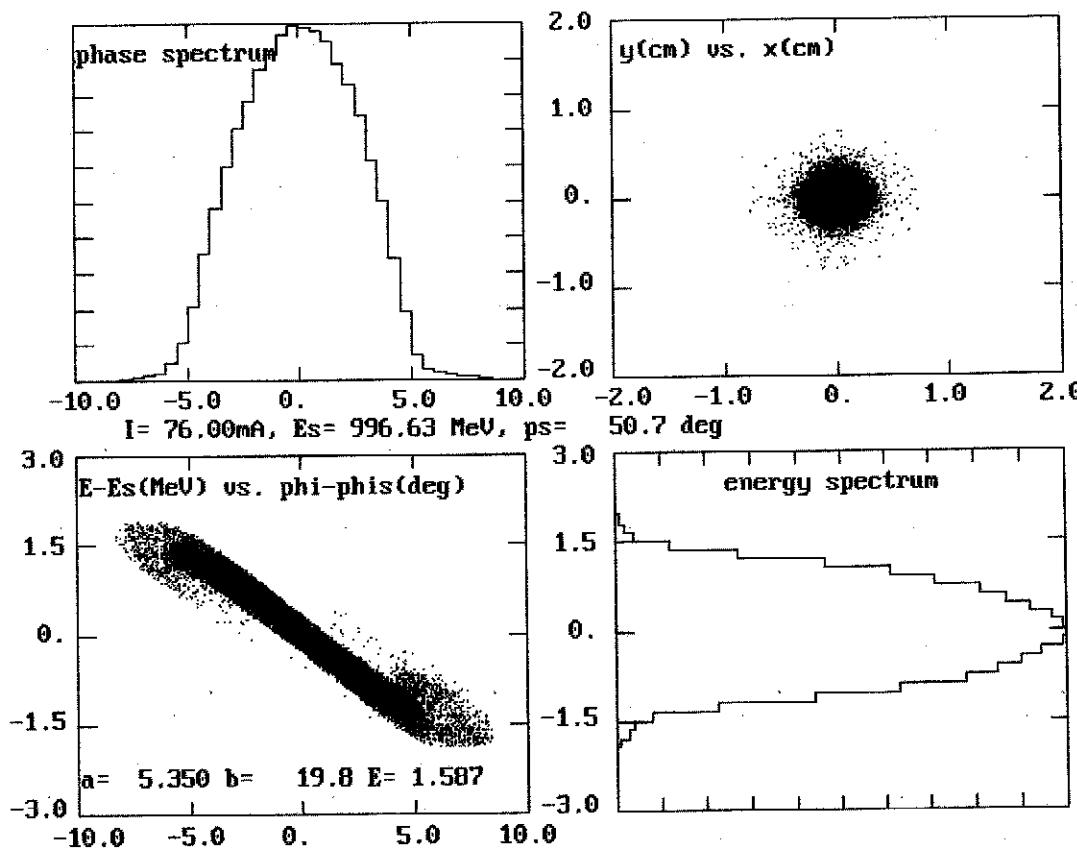
Phase Space Projections at Linac End for the $E_0 \pm 50\%$ Case



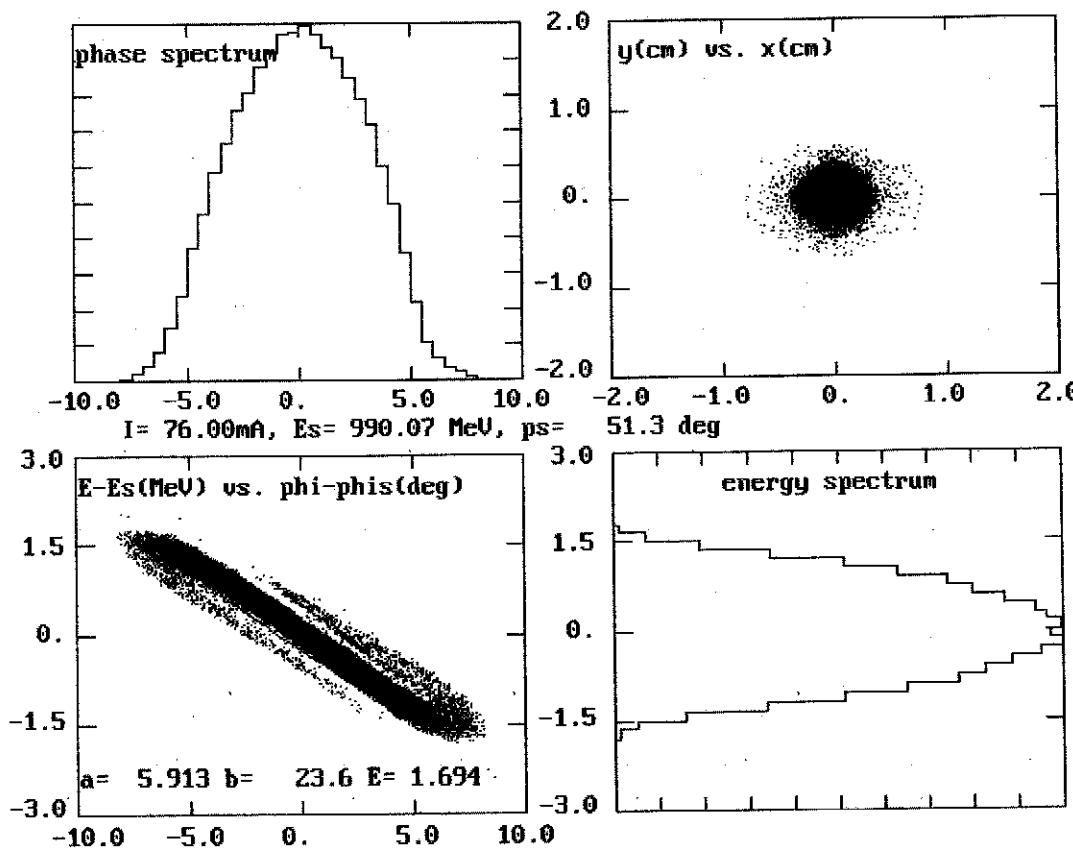
Phase Space Projections at Linac End for the Design Case



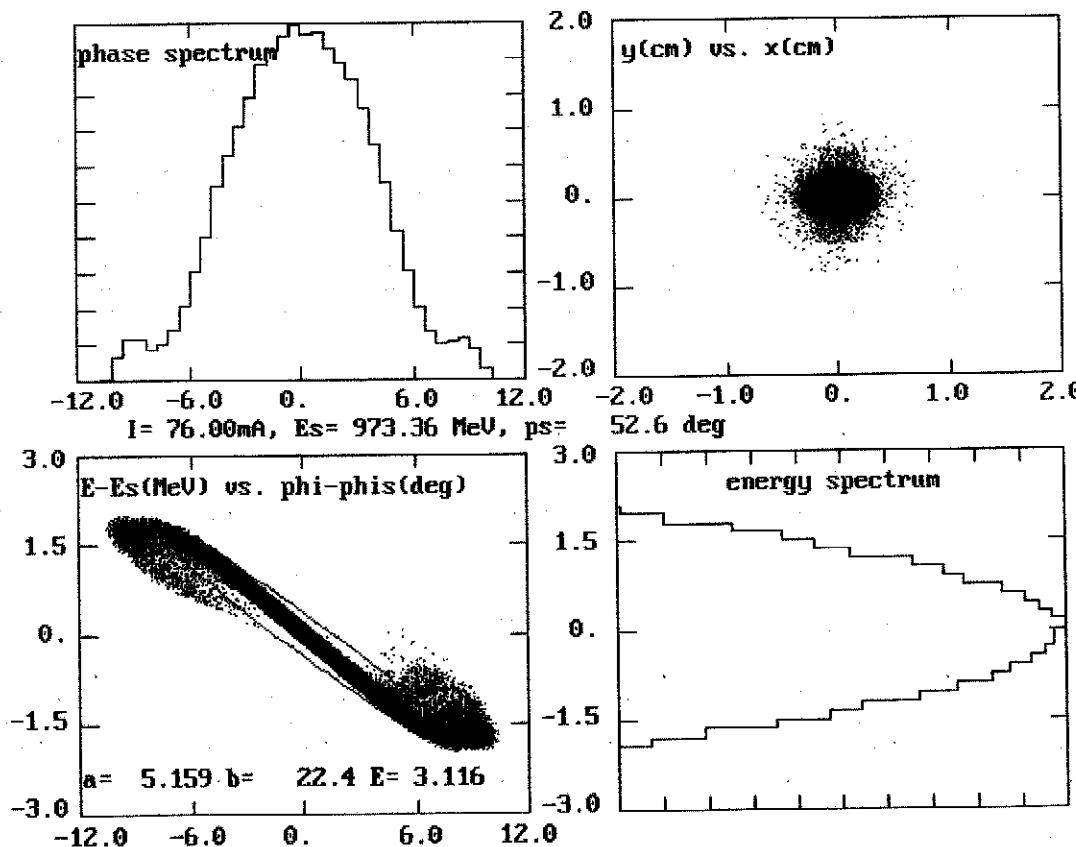
Phase Space Projections at Linac End for the $E_0 \pm 10\%$ Case



Phase Space Projections at Linac End for the $E_0 \pm 30\%$ Case



Phase Space Projections at Linac End for the $E_0 \pm 50\%$ Case



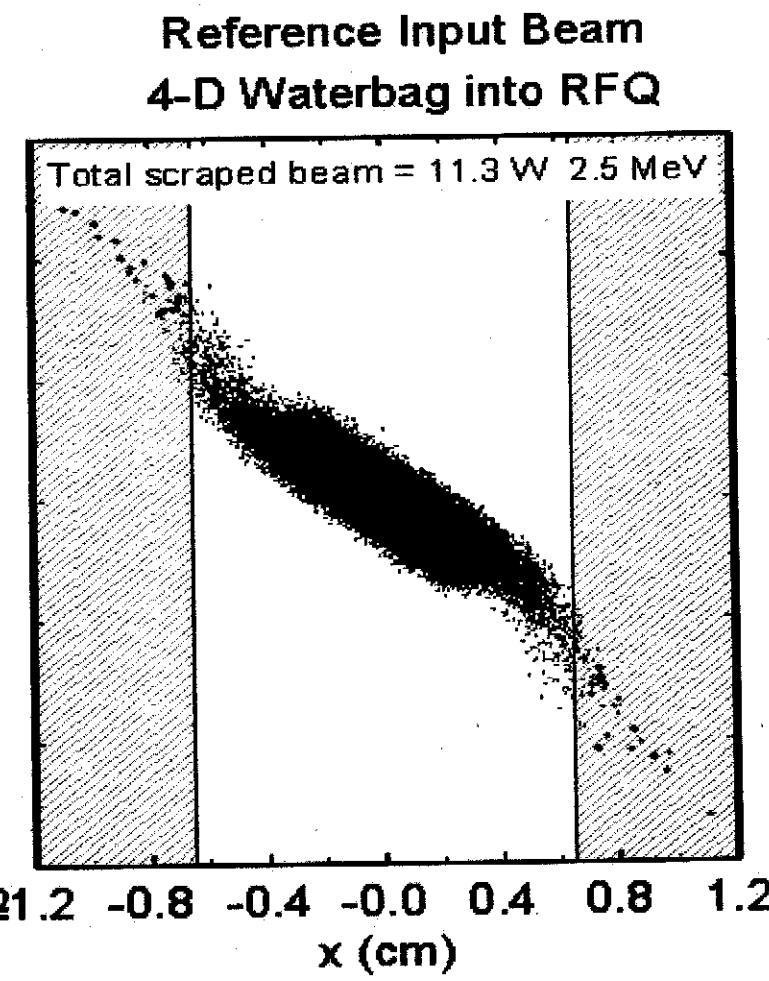
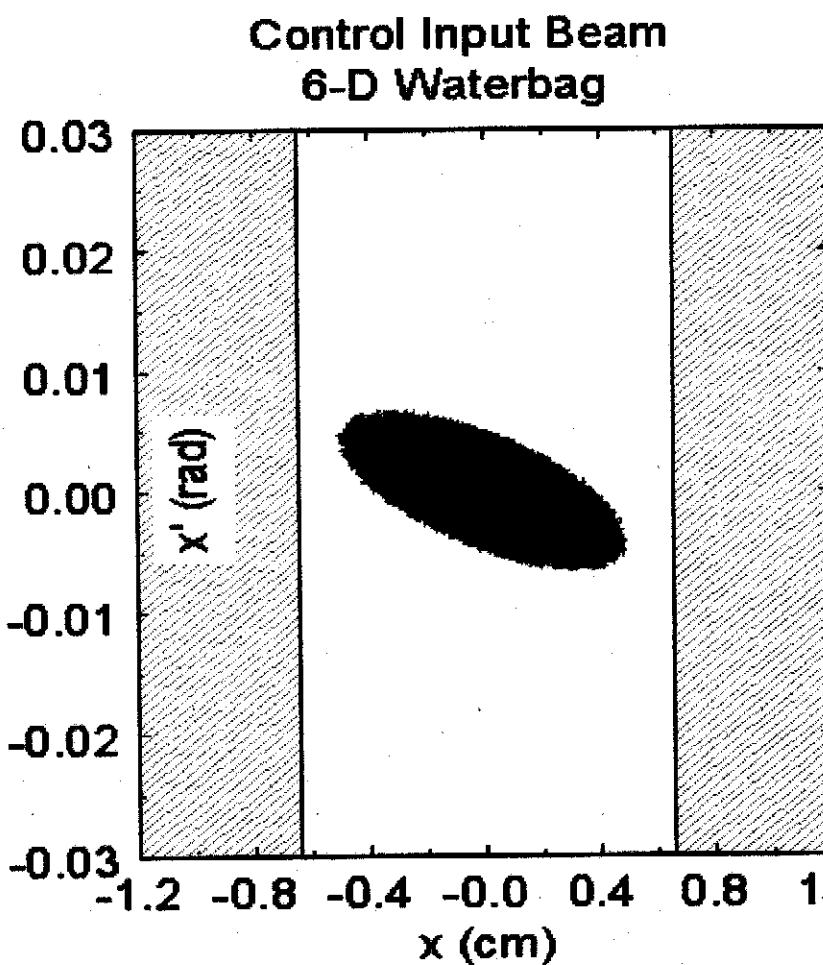
Average Emittance Values for $E_0 \pm 10\%$ Case is not Different from the Design Case

Emittance $\epsilon_{99\%}$ (π cm-mrad)	Input	Design	$\langle \epsilon_{99\%} \rangle$ for $E_0 \pm 10\%$	$\langle \epsilon_{99\%} \rangle$ for $E_0 \pm 30\%$	$\langle \epsilon_{99\%} \rangle$ for $E_0 \pm 50\%$
x	.250	.405	.405	.432	.498
y	.231	.253	.254	.269	.323
z	.257	.334	.344	.431	.766

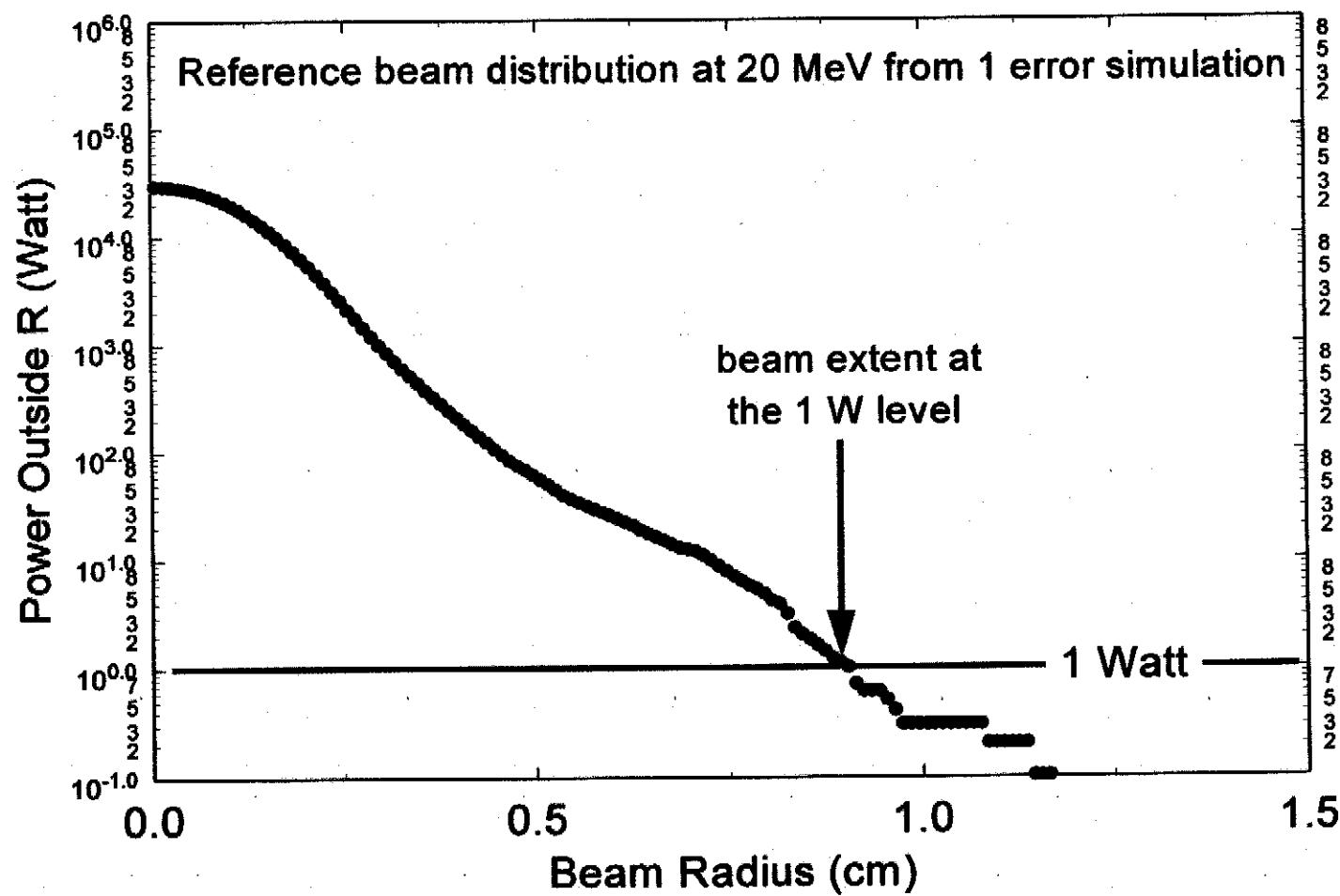
Implication of the Results

- The SRF linac structure in its present rf powering scheme is surprisingly tolerant to large variation in E_0
 - Constant ϕ_s for varying E_0 is a deviation from the design tune
 - Results in a distributed longitudinal mismatch
 - Longitudinal mismatch has little effect on transverse dynamics
 - the same cannot be said about conventional coupled cavity linac layout
 - Has significant impact on commissioning; provides considerable leeway in setting phase and amplitudes
 - Has to meet requirement on W- and ϕ -spread for injection into ring
 - Strongest of all the arguments in favor of a using SRF linac structures at higher energies
-

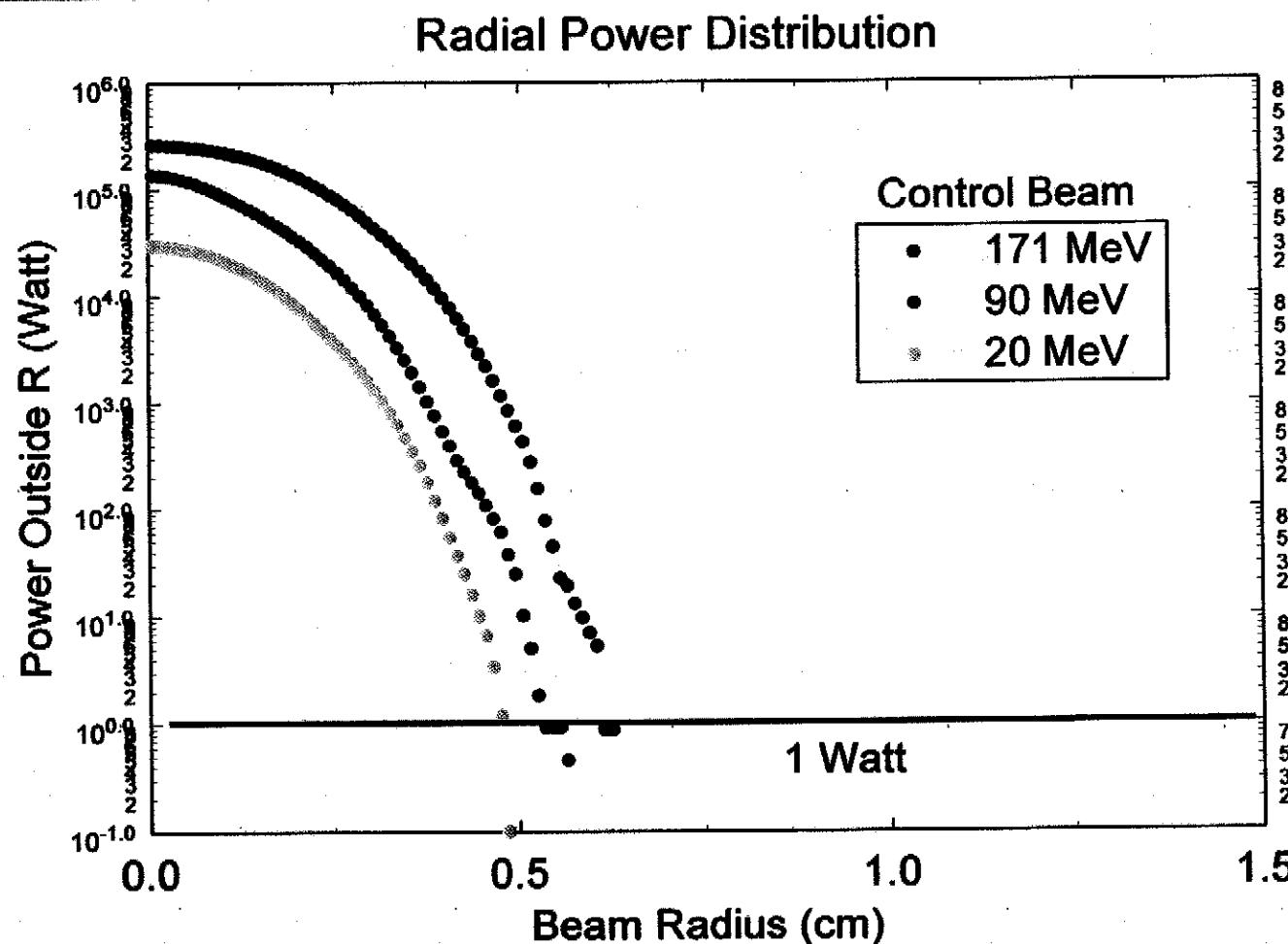
Design Studies Use a “Control” Input Beam Error Studies Use “Reference ” Input Beam



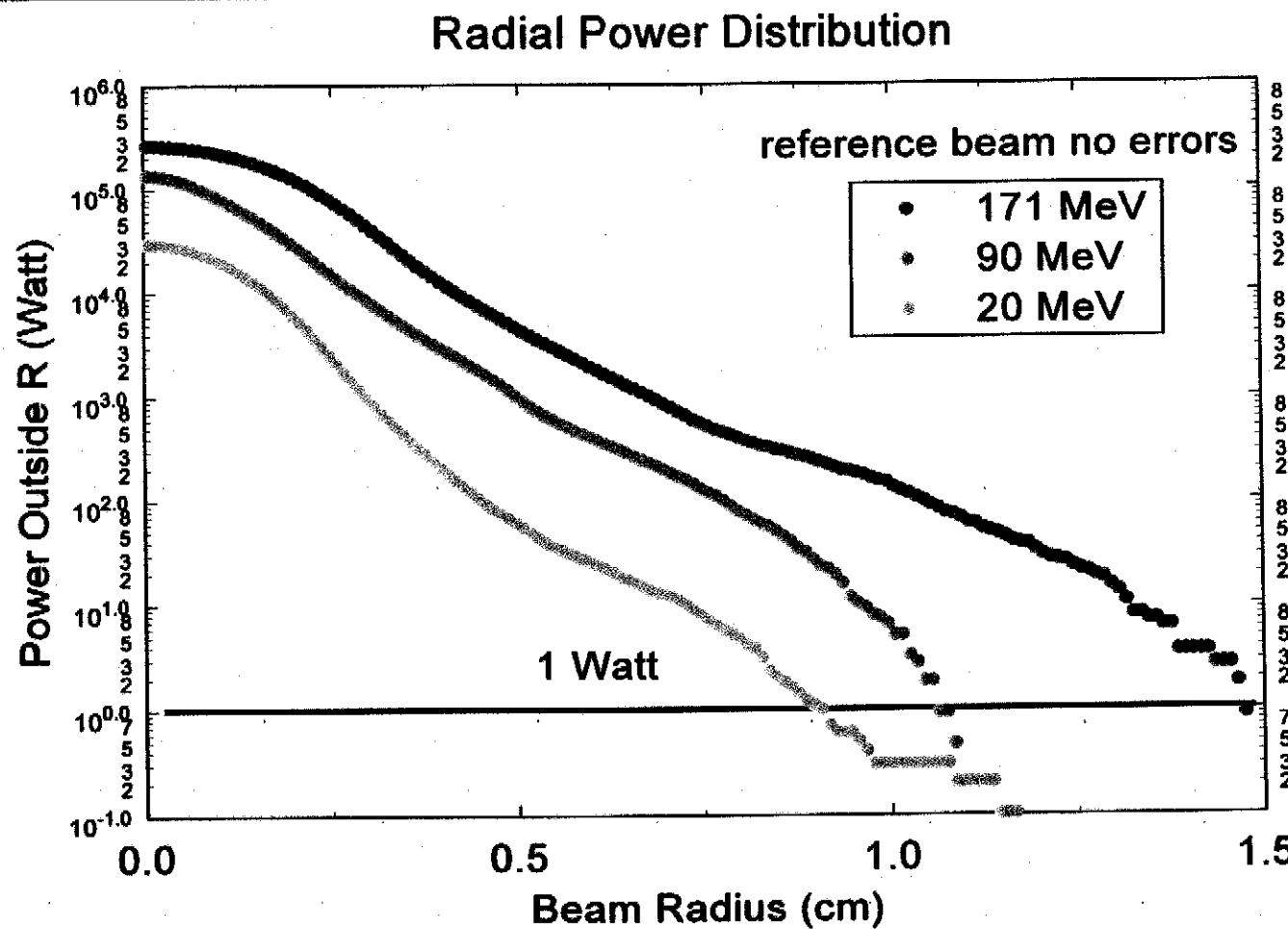
A Radial Power Distribution Defines the Beam Edge at the 1 Watt Level



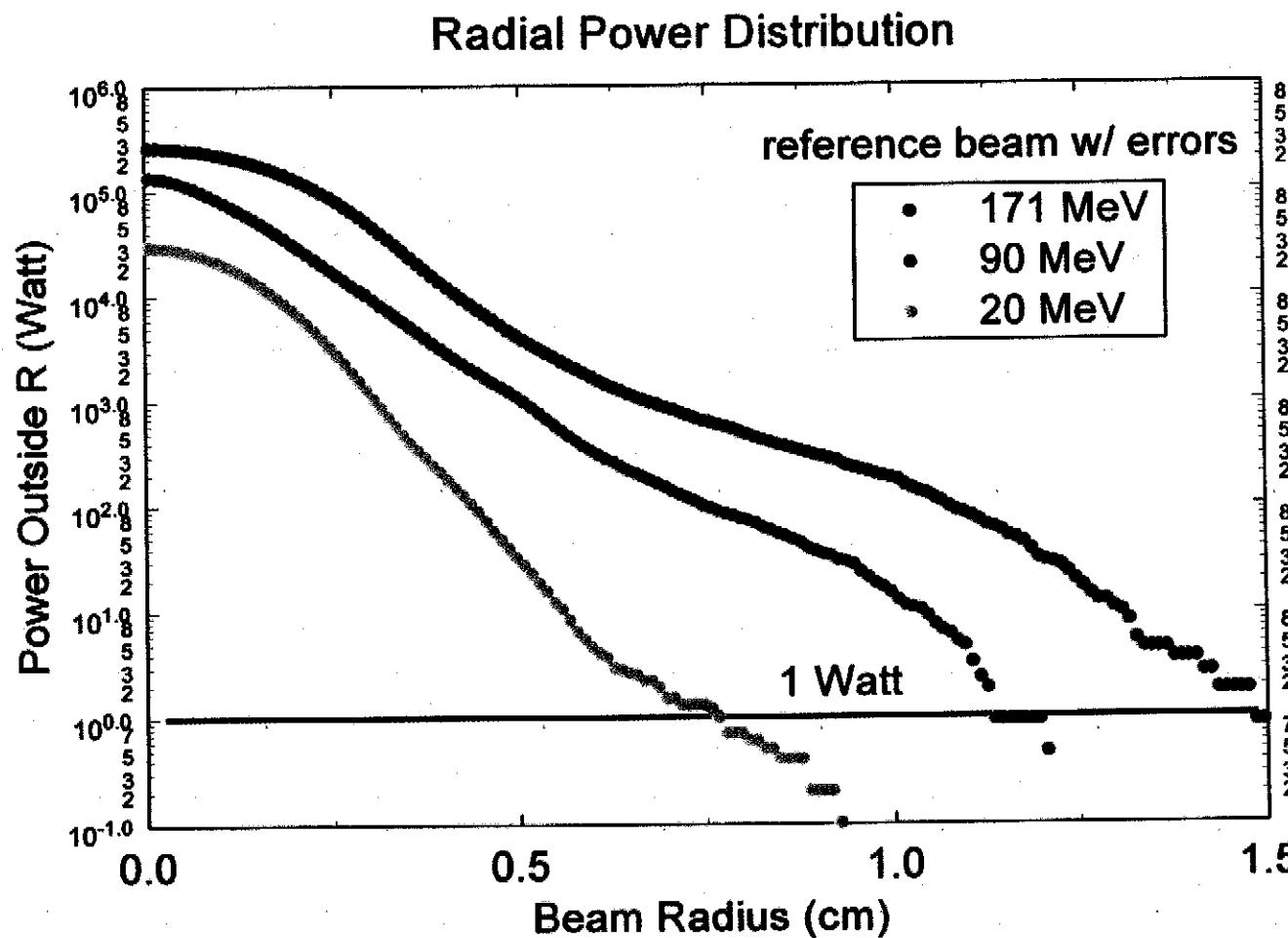
Control Beam Develops Very Little Halo



Reference Beam Without Errors Develops a Significant Halo



Inclusion of Errors Has Little Effect on Reference Beam Distribution



Maximum Expected Beam Extent at the 1-Watt Level Occurs in the CCL

5nA per particle, all errors included

